NASA: THE SCIENTIFIC IMAGE

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PREFACE

Research is an exercise in decision-making where the goals are many and ill defined and the ways of reaching them only dimly perceived. At every stage of the process, from initiation to completion, the researcher has to make choices about what to do: what he wants to study, what methodology he ought to use, what specific questions to ask and how to word them, who to interview, how to organize his data, what statistical tests, if any, are appropriate, what to report, how to phrase his report and assess its significance and so on. Furthermore, he does not make his choices in a political or social vacuum. Not only must he wrestle with himself and his own biases, limitations, and mental processes, he must wrestle with others. Those who work with him or for him, those who make resources available to him and have certain expectations about what he will do, those who he hopes will answer his questions, those who he expects will read about whatever he finds. He also has his own career to be concerned about. The public results of his research usually conceal, sometimes skillfully, sometimes not so skillfully, depending on the symbols or format used in presenting them, the long string of choices and compromises which have been made in arriving at them.

The normative model which the researcher is supposed to follow in all of this, the model in which he is indoctrinated as he goes through the process of becoming a 'social scientist,' bears a remarkable resemblance to the modes of rational decision-making which administrators and 'economic men' are said (or supposed) to follow.

He should proceed carefully from thought to action, one following the other in that sequence. He is to work out his theories and concepts, clearly and logically, deriving from them 'testable' hypotheses (goals). Next he develops a design - the best one, mind you - for collecting data and examining them (means). After appropriate thought he accepts or rejects the hypotheses, according to certain explicit, rational criteria, and then moves on to his next problem. Where the businessman, say, maximizes profits, the social scientist attempts to maximize contributions to knowledge or some such thing. The way to do this, presumably, is by following the model carefully and 'rigorously', always assessing each alternative in light of this desired end.

Unfortunately this model is misleading - both for the administrator and the researcher - in so far as it is taken as a description of what he in fact does or even comes close to doing. He does not have the time, wits, capacity, or resources to maximize. The model may serve simply to hide this fact or else as a source of guilt since he 'didn't do it the way he should have'. It may also be misleading as a prescriptive guide for decision-making, especially in the case of research, both because of the guilt feelings it tends to produce and because it limits the imagination and inventiveness of the researcher. Compulsive adherence to it, or a close approximation thereof, may produce a 'trained incapacity' to think imaginatively.

At few other times in the research process does its decision-making character become more apparent than when one sits down to prepare a report like the one which follows. The trade-offs which must be made between one set of values and another in producing it become clearly (and painfully) obvious. Specifically, from the point of view of a policy-maker, unless such a report comes out almost immediately after the data is collected the relevance of its findings are questionable or merely of historical interest. He has to make decisions <u>now</u> and doesn't have time to wait until all the facts are in (they never <u>are</u>, of course) or all the issues clear. Furthermore, if there is too much of a time lag, he can always claim, often justifiably, sometimes as a defense mechanism, that conditions have already changed so much that the data are no longer relevant or 'true'. Finally, he often wants the results to be stated in 'simple, straight-forward conclusions' and doesn't want to be bothered with all of the qualifications or rationale which are the hallmarks of the academic. He hasn't the time or patience to wend his way through all of the (tortured) prose which preceeds a statement. For action purposes he needs a simple answer: Yes or No! More or Less! Stop or Go! Good or Bad!

On the other hand, the researcher is faced by a mass of data and has certain norms about how it ought to be treated. There are a number of alternative ways in which this mass can be profitably divided up, analyzed and presented. There is no clear-cut, one-best way for doing it: each has its advantages and disadvantages.

Especially when one is just beginning his analysis, as is the case in this study, the uncertainties of where to begin and how to order things are immense. While there is never any final, best answer, some are probably better than others, depending on the criteria being used. Unfortunately, selecting the criteria takes time, evaluating alternative ways of analyzing and presenting the data takes even more time. Finally, reducing a rather complex analysis to a few simple statements is difficult if one is to do justice to the complex meaning of the results.

This report thus represents a compromise (which may satisfy no one) between the need to get it out as soon and in as straightforward a language as possible, and the desire to do a maximally respectable job with limited resources and skills. Rightly or wrongly, it was assumed that the results were of some interest to decision-makers in NASA and elsewhere since this seemed to be included, at least implicitly, in the terms of the original grant under which this study was done. The results are clearly of interest to those who participated by completing questionnaires since over three-fourths of them asked for a copy of them.

As a consequence of this compromise (and compromises of some sort are always involved), only very crude measures of certain important variables are used and only the very simplest types of analytic techniques and statistical tests are employed. The development and refinement of more sophisticated indicators for the variables and the use of more exotic analytical models would have taken more time. They will come later as the analysis preceeds, and, in the meantime, we have at least a pretty good idea of what they will probably show. In addition, only a small part of the data collected in the study (probably about 5%) has been used in the present report. Much remains unconsidered at this point though work is proceeding. This 5 per cent was selected largely because it seemed, intuitively, to be an easy and interesting place to begin. The findings would, at this point, seem to substantiate the soundness of this judgment.

INTRODUCTION

In the years since the successful orbiting of Sputnik I, there have been numerous attempts by political and administrative officials to specify the goals of the U.S. space program, both what they are or have been and what they ideally should be. The initial efforts in this regard occurred during the debates surrounding the eventual passage of the National Aeronautics and Space Act of 1958. This legislation created a civilian agency, NASA, headed by an Administrator with direct access to the President and assigned to this organization formal responsibility for pursuing a variety of more-or-less concrete objectives. Since that time, as the political and technological environment within which NASA operates has shifted, so have the priorities attached to these various objectives.

During its fledgling years its basic character and, in fact, its long-run future was in considerable doubt. Was it going to continue in the direction of the National Advisory Committee on Aeronautics as a modest, low-key applied research agency for the aero-space industry and the military? Was it going to follow in the footsteps of NSF and NIH, providing grants and technological apparatus to university scientists for the unhurried, careful scientific investigation of the atmosphere and space? Would it go all out in competition with the Russians to recoup the prestige which many Americans felt had been lost? Would it be able to survive pressure from the Air Force and some of that agency's key supporters in Congress for a significant part in the space program?

These issues were still unresolved when President Kennedy announced in 1961 that he was committing the nation to a program to land a man on the moon by 1970. This gave new impetus, drive and a sense of direction to the whole space program and resulted in the harnessing of vast national resources in the name of an essentially politically motivated objective. It also created a situation in which other NASA objectives and the constituencies to which they seemed important tended to be overshadowed if not occasionally lost sight of. Now with the approach of the first successful manned lunar landing, still another new environment for the organization will come into existence.

As with any organization which has a finite goal, accomplishment of that goal creates a crisis situation. One alternative, of course, is for the organization to go out of "business". For a number of reasons including the factor of sunk costs, both in material and human terms, the pressures arising from groups in the organization's environment who have, in one way or another, become dependent upon it for their own existence this stark alternative is seldom, if ever, selected. Such pressures are very clear in the case of NASA. Another alternative is for an organization to be dismembered and for different groups within it to be absorbed into some other ongoing units with goals of their own. While this happens with greater frequency, it too poses a threat both to the esprit d'corps of those involved and the delicate political-social equilibrium which has been worked out with the environment over the years.

Thirdly, a kind of informal "succession of goals"[1] may occur with a new set of de facto if not de jure objectives arising as the result of changes in the leadership of the organization, changes in the social composition of its members, or its alliances with and commitments to various powerful groups in its environment. In some instances, even in a public bureaucracy such as NASA, this may serve as a partial substitute for having to redefine, formally, major organizational intentions.[2] This might be cited as an example of incrementalism in goal definition: rather than raising anew the entire question of what kind of an organization it ought to be or whether it even ought to be continued, goals are adjusted gradually, at the "margins" so to speak, and basic issues are never raised and the process of goal adjustment is relatively invisible to all. That this succession has occurred at all becomes apparent only in retrospect. A final alternative, of course, is to seek a formal, explicit redefinition of organizational goals and, in the case of a public bureaucracy, to receive from the political system a new commitment, a new statement of long-run obligations. At present it appears that NASA is attempting to steer a middle course between these latter two alternatives.

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1. Blau, Peter M., Bureaucracy in Modern Society (N.Y: Random House, 1956), pp. 95-96.

2. For example, see Philip Selznick, TVA and the Grass Roots (Berkeley and Los Angeles: University of Calif. Press, 1949) and Burton Clark, The Open Door College, (N.Y.: McGraw-Hill, 1960).

Already there are many signs that some of the earlier political and popular support for the program is beginning to wane and that NASA officials are casting their nets widely for new goals and commitments or at least a redefinition of past purposes which will enable them to maintain and justify the continued use of the engineering-management capabilities which have been built up over the decade. At one level this is occurring through the proliferation of in-house and contractual studies which examine in detail how space technology might be exploited further and applied to such problems as weather prediction and control. In a similar fashion numerous grants and contracts have been given to groups to study possible innovations in the use of NASA management technizues or technology for the solution of a range of social problems - crime detection, waste disposal, air pollution, urban congestion. At another level, attempts are being made to get a formal recommitment if not a formal redefinition of goals and priorities from the political system.[3] Without such a commitment the future character of the agency, even its existence at a level approaching that of its present operations, is in considerable doubt.

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3. Hearings Before the Committee on Aeronautical and Space Services, U.S. Senatc, 89th Congress, 1st Session, <u>National Space Goals for the Post-Apollo Period</u> (Washington, D.C.: U.S.G.P.O., 1965) and the newly issued report of the President's Scientific Advisory Committee on Space Goals reported in the <u>New York Times</u>, Feb. 12, 1967, p. 1.

In this light it seems particularly imperative to inquire into the responses of the scientific community to the space program to date. Up to now, research and exploration of the unknown have given a certain elan, a certain sense of excitement to many of those who work for or with NASA. Without this element the agency would probably lose many of those who are motivated by such opportunities and, in becoming essentially a technical organization concerned with the exploitation of a limited range of technology, would undergo a substantial shift in self-definition and change in personnel. The use of technology to "solve" social problems can also be an exciting undertaking, of course, but most certainly it would tend to appeal to a different type of person than does research on the frontiers of space. It also raises the question of whether or not NASA, as it is presently constituted, is the best organization to take responsibility for such activities. On the whole, engineers and scientists are not, as professional groups, noted for their understanding of or sensitivity to socio-political systems. Basic research and the conduct of elaborate scientific investigations in space and on the various planetary bodies, on the other hand, could potentially provide some of the needed legitimacy for the continuation of NASA at or near its present level of operation and, at least in the short run, avoid such difficulties.

This, however, assumes that scientists see NASA as an agency in which they have some degree of influence and with which they can work without having to give up substantial control over their own definitions of what constitutes "good science," what research they want to do, and how they want to go about it and not be inundated by red tape and rigid time schedules and overwhelmed by technology. It also assumes that many of them feel or can be brought to feel that something of substantive value to science can accrue from a massive commitment to space and planetary research. This has to be weighted, of course, against the possible benefits to science and mankind from alternative uses of these same resources, assuming that political realities make such alternative commitments likely.

A second important reason for inquiring into the image which the scientific community has of NASA is that the agency has had, since its inception, the explicit goal of expanding "...human knowledge of phenomena in the atmosphere and space..."[4] While this goal has generally been overshadowed by the more spectacular and costly manned space flight program, in the name of such an objective NASA has created a rather extensive space science program over the years. It involves all major universities in some degree and several thousand scientists and engineers both within these

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4. Staff Report, prepared for the Committee on Aeronautical and Space Sciences, U.S. Senate, 87th Congress, 2nd Session, <u>National Aeronautics and Space Act of 1958</u> (Washington, D.C.: U.S.G.P.O., 1962), p. 2.

universities and within the agency's research centers. During fiscal year 1964, for example, the programs within the Office of Space Science and Applications, which has explicit responsibility for this aspect of NASA's activities, accounted for approximately 12 per cent of the personnel directly involved in flight programs in the agency and almost 17 per cent of the total research and development budget.[5]

This interaction between the space agency and its scientific environment has taken several forms. The largest share of its support of research in the universities has gone for projects oriented towards specific missions. As one commentator has suggested, it may be this "...project-type research that determines the image of NASA held by the academic community."[6] In addition, however, the Sustaining University Program has supplied funds for constructing buildings and other research facilities at some dozen places plus sizeable grants for basic research and traineeships for over 1,000 students at more than 100 universities.[7] By the Spring of

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5. U.S. Congress, House, Committee on Appropriations, _Independent Offices Appropriations for 1963_, Hearings, 87th Congress, 2nd Session, Part 3, pp. 511; 1039.

6. Montgomery, D.J., _Final Report to the National Aeronautics and Space Administration on a Study of NASA-University Relations_ (East Lansing, Michigan; Michigan State University, 1965), pp. 11-12.

7. _Ibid._, pp. 15-16.

1965 approximately forty-five successful space shots carrying one or more scientific-technological experiments had been launched, ranging in variety and purpose from the Ranger series, bearing few experiments, to several orbiting satellite laboratories carrying anywhere from thirty to fifty experiments on board. This figure does not include a number of balloon flights and sounding rockets which have also carried experiments aloft for scientists.[8] Finally, to help in the planning and direction of these numerous efforts the agency, sometimes with the help of the National Academy of Science, has proliferated a multitude of formal and informal, permanent and ad hoc advisory committees and special study and review panels a majority of whose membership has been drawn from the scientific community.

Thus NASA has succeeded in creating an elaborate network of alliances with certain segments of the university and scientific world. Its support of scientific work in the atmosphere and space has used up a significant share of the available resources and the results, potentially, can serve to legitimate these efforts to both the political and scientific community. The question to be asked now is: What value, in terms of scientific pay-off, do scientists associate with the program to date? If that value is deemed to be high then the argument that conducting science in

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8. National Aeronautics and Space Administration, Report to the Space Science Board, National Academy of Sciences (Washington, Sept. 1964).

space can partially justify the past and possibly future expenditure of national resources for an extensive space program is given additional weight. If it is deemed to be low then it raises some serious doubts about past decisions and future directions (or else about the broad-mindedness and long-range thinking of the scientific community).

Research Design

In order to examine some of these issues in detail, a structured, self-administered questionnaire was designed for mailing to a sample of respondents drawn from several different populations of scientists. The subject matter which it covered was based on some hypotheses about decision-making in science and the effects of Big Science on the organization of research, hypotheses derived from a reading of previous work in these areas and extensive semi-structured interviews conducted over the period of a year with almost 50 university scientists involved in space research plus another 50 or so NASA managers and scientists. Only a portion of the results are reported in the present paper.

After a pretest of the instrument, a total of 2,503 questionnaires were sent to scientists whose names were drawn by a random process from one of three sources: (a) the membership listings of the National Academy of Sciences; (b) the 10th and, where possible, the 11th edition of American Men of Science; and (c) a list of all those scientists from universities, government or industry who have participated in the space science program in NASA in any fashion including such things as receiving a research grant between 1958-65, having a flight experiment of any kind or being a member of a NASA Science Advisory Committee or a space science panel or study group of the National Academy of Sciences from 1957-65. When a name appeared on more than one list, precedence was given to the list of space scientists and another name was drawn for the other group.

After a follow-up letter and, finally, a follow-up questionnaire the number of usable returns was 1,295 (52%). Of the remainder, there were 265 (11%) refusals, 271 (11%) which were returned either because of a lack of a current address or because the respondent was deceased, and 632 (26%) of which no kind of response was received. In light of the fact that the survey instrument was almost 20 pages long and, on the average, required 45 minutes to complete, this would appear to be a rather impressive return. As can be seen from Table 1, the response rates varied somewhat by sub-groups.

The lowest rate of return was from respondents at NASA headquarters whose names were selected because they appeared on our list of space scientists. Only 30 per cent of them completed the questionnaire, 20 per cent sent back refusals and almost half (45%) did not bother to respond in any fashion to repeated inquiries. The next lowest proportion of completed questionnaires was from those selected on the basis of their membership in the National Academy of Science. Only a little over two-fifths of them filled out and returned our questionnaire while a majority (55%) either explicitly refused to respond or else ignored our requests altogether.

As might be expected, the highest rates of return were from those most directly involved in the research aspects of the space program: university space science researchers (58%) and NASA field center scientists and managers (56%). In terms of their scientific or managerial careers it is these individuals who have made the greatest commitment to the program and thus have the greatest vested interest in its character, direction and affect on them. Furthermore, they would be the ones most likely to feel that their answers might have some positive influence on policy makers in the space sciences area in NASA. The questionnaire can be seen as an alternative, anonymous, non-threatening way to communicate views, popular and unpopular, to headquarters decision makers.

Table 1.

This table shows the disposition of questionnaire returns by sample sub-groups.

	DISPOSITION OF QUESTIONNAIRES				
	Per cent of:				
	Completed	Refusals	Undelivered, Deceased	No Response	(N)
NASA:					
Field Centers	56%	3%	13%	28%	(207)
Headquarters	30	20	5	45	(56)
Other Space Scientists:					
Universities	58	13	7	22	(528)
Other	53	8	21	18	(195)
National Academy of Science	42	29	3	26	(277)
American Men of Science	51	6	15	27	(1,236)

The sharp differences in response rates between NASA headquarters and field center personnel undoubtedly reflect several things. Most important is probably the fact that the former group has formal "program responsibility" for space science and thus, in a very real sense, was being asked to comment on themselves or their immediate administrative superiors. This would require a considerable amount of self-confidence and security. Those at the field centers more often see themselves as scientists on a par with scientists elsewhere and they tend to feel considerable autonomy from and sometimes antagonism towards headquarters officials. Thus they are both more free and more motivated to comment on the character of the program.

Another way to view the questionnaire returns is to consider them in light of the disciplinary identification of the respondents. This is especially critical since it was anticipated that scientific discipline would be a key variable for explaining the reaction of scientists to the space program. This issue is dealt with in Table 2.

Almost two-thirds of those individuals who identified themselves as being in astronomy or one of the various atmospheric or earth sciences filled out and returned the questionnaire. As we shall see later (Tables 5 and 6 below) these areas are among those most intimately involved in space research. With the exception of mathematicians, a majority of all the other scientists whose disciplinary backgrounds are known also completed and returned our survey instrument. Forty-three per cent of those in mathematics did so and as we shall also see this particular discipline is among those least affected by the space program to date. Only a little over a quarter of those (28%) whose scientific specialties fall outside the range of those shown in the table or else are unknown responded. This, of course, is understandable since, in part, their failure to participate in the study made it impossible to ascertain their background.

Table 2.
This table shows the disposition of questionnaire returns by disciplinary self-identification.

	DISPOSITION OF QUESTIONNAIRES				
	Per cent of:				
Disciplinary Self-Identification	Completed	Refusals	Undelivered, Deceased	No Response	(N)
Astronomy	65%	14%	6%	15%	(110)
Atmospheric and Earth Sciences	66	8	8	17	(191)
Biology, Life Sci.: Bio-chemistry, Bio-physics, Genetics, Microbiology	55	14	10	20	(260)
Other	55	13	8	24	(291)
Chemistry	54	6	15	24	(567)
Engineering	54	8	17	21	(230)
Mathematics	43	13	14	30	(77)
Physics	52	11	8	28	(447)
Other and Unclassified	28	14	19	39	(330)

Let us focus, finally, on the disciplinary and work characteristics of those who responded to our questionnaire. Consider first the association between sample sub-groups and scientific background. The data in Table 3 shows some rather substantial differences in this respect between space scientists, including those in NASA,

Table 3.

This table shows the disciplinary self-identifications of respondents by sample sub-groups.

Sample Sub-group	Astron	Atmos & Earth Science	Bio	Chem	Engr	Math	Physics	Other
NASA	18	15	7	3	22	1	23	9
Other Space Science	19	15	19	6	13	1	21	6
National Academy of Sciences	0	3	49	20	2	9	10	6
American Men of Science	1	2	26	38	13	4	14	2

on the one hand and those drawn from the National Academy of American Men of Science on the other. Few of our respondents in NASA are in fields of chemistry, biology, or mathematics while engineering and physics combined account for 45 per cent of the total. The proportion of biologists among other space scientists (19%) is somewhat higher and the proportion of engineers (13%) is somewhat lower than it is for those employed by the space agency, but the proportions of physicists and those in the astronomical, atmospheric and earth sciences is almost the same. In contrast, those whose names were taken from our other two lists of scientific populations are predominantly in the biological and chemical sciences with physics running a poor third. Only a handful identify themselves either as astronomers or as atmospheric-earth specialists.

Now let us consider the relationship between sample sub-groups and the types of activity-management, research and teaching-in which our respondents say they are primarily engaged. NASA - affiliated individuals are the most likely to be managers of some

	Proportions who are in:				
Sample Sub-group	Management R&D	Management Other	Basic Research and Teaching	Applied Research and Development	Other
NASA	46%	5%	26%	19%	5%
Other Space Scientists	35	4	53	7	3
National Academy of Science	16	3	73	1	6
American Men Of Science	23	10	44	16	7

sort or another (51%) and the least likely to describe themselves as basic researchers or teachers (26%). At the other extreme, almost three-fourths (73%) of the scientists from the National Academy sample see themselves as being in basic research and less than one-fifth (19%) report being in management work. The next highest proportion of scientists in basic research (53%) occurs among those outside of the agency involved in space research but also this same sample contains the second largest proportion of managers (39%). One-third of our respondents selected from American Men of Science have managerial duties and 44 per cent are in research and teaching.

In conclusion, NASA respondents are primarily managers, those from the National Academy primarily researchers and those identified as space scientists or drawn from American Men of Science are split somewhat unevenly between management and research with the division favoring the latter activity. Those selected from our population of space scientists are predominantly physical scientists and engineers while those drawn from other scientific populations are more likely to be in biology and chemistry.

Findings

INVOLVEMENT IN SPACE RESEARCH

To set the stage for the main thesis which we wish to pursue in the subsequent analysis -- that the images which scientists have of NASA and the value of the space program to date are strongly associated with their identification with a particular scientific subfield and the degree of its involvement in space science -- let us examine the proposition that scientists in various scientific disciplines have been differentially involved in the space program, have different degrees of commitment to it and different sources of potential information about it. One step in this direction was taken already when we examined the disciplinary background of our respondents by sample source and found that those drawn from the list of space scientists tended to be physical scientists and engineers. Even more dramatic evidence of this fact, however, is presented in Table 5.

Table 5. This table shows the perceived centrality of the space science program to various disciplines by scientific specialty.

	Proportion who said discipline interest was:		
Disciplinary Self-identification	Central	Marginal	Non-existant
Astronomy	67%	33%	0%
Atmospheric and Earth Sciences	60	40	0
Biology, Life Sciences: Bio-chemistry, Bio-physics, Genetics, Microbiology	5	87	8
Other	8	86	6
Chemistry	10	84	6
Engineering	46	52	2
Mathematics	5	85	10
Physics	44	51	2

Our respondents were asked: "Are scientists in your discipline centrally or only marginally interested in the space science program at present?" Clearly for astronomy and the atmospheric and earth science specialties, research in space seems to have offered exciting and worthwhile opportunities. Two-thirds of the scientists identifying themselves as astronomers and three-fifths of those indicating a background in atmospheric-earth disciplines ascribed a position of central interest to work in the space science program. Engineers (46%) and physicists (44%) were substantially less unanimous in accepting this position while scientists in biology, chemistry and mathematics were almost unanimous in their <u>rejection</u> of space research as a subject of central concern to them or their colleagues. At the same time, however, only a small minority of our respondents were willing to subscribe to the opposite extreme view: that this program held absolutely <u>no</u> interest for people in their disciplines. Most were willing to admit at least some marginal interest in work in space.

<u>Laboratory vs. Space Research</u>

The place of work for the empirically oriented scientist has typically been either in the laboratory or in the field. While the mathematician or theorist may need little more than a desk, a chair and paper and pencil, the work of the experimentalist or the descriptive scientist takes place in a more specialized environment complete with measuring devices and, often, some form of technical assistance. For the first time the technology which NASA has developed makes feasible research in the atmosphere and space on a scale and in a fashion hitherto impossible. We would expect this work to have differential consequences for various scientific disciplines since the space environment would seem more theoretically or empirically relevant for some than others. Thus, another indication of the differences among scientific fields in their involvement in, and dependence on space research would be the way in which scientists in different areas evaluate the potential value of earth-based as opposed to space-based research. This issue is examined in Table 6.

Table 6.

This table shows scientists' perceptions of the potential relevance of earth-based vs. space-based research for their field by scientific specialty.

	Proportion rating as most promising:		
Disciplinary Self-identification	Space-based Research	Earth-based Research	Both Equal
Astronomy	39 %	17 %	44 %
Atmospheric and Earth Sciences	32	22	46
Biology, Life Sciences: Bio-chemistry Bio-physics, Genetics Microbiology	5	71	24
Other	9	66	25
Chemistry	5	73	22
Engineering	22	38	40
Mathematics	6	62	32
Physics	24	50	26

Several things stand out from the table. First of all, no discipline appears to be totally dependent for its future upon NASA and the technology it has made available, though some are certainly more so than others. However, even among astronomers and atmospheric-earth scientists we find that only approximately one-third view space-based research as the critical wave of the future. A larger proportion - 44 and 46 per cent respectively - subscribe to the view that both space and more traditional laboratory or field work are of equal potential while close to one-fifth of them still single out earth-based research as most important.

Secondly, no discipline will apparently be unaffected by what might happen in the space science program. Even a small percentage of biologists, chemists and mathematicians rate the potential of space-based research highest and a larger number are willing to rate space work at least as equal in potential to that conducted on the ground. At the same time it is evident that from over two-fifths to almost three-fourths of them continue to place their greatest faith in the traditional way. Finally, physics appears to fall in between these other disciplines. Only half of the physicists select earth-based work as holding most promise for their field while the other half is divided in its judgment on the centrality of research in space over laboratory work.

Commitment to NASA

What of the commitment felt by scientists in different disciplines to NASA as an organization? Would they like to see it expanded relative to other agencies? Do they believe that the work which it has made possible could have found a home elsewhere or has it been dependent solely on the existence of this particular organization? Consider first the association between disciplinary self-identification and whether or not an individual feels that the share of the Federal R & D budget - 15 billion in 1965 - which NASA received, approximately 5 billion, should have been greater, less or was about right. This will give us one indication of their commitment to NASA as a total organization.

As it turns out, the major differences are not between those who feel NASA should have received more and those who feel that it was over-supported, but between those who viewed the level of funding as adequate and those who thought it should have been cut back. Once again the greater involvement in and commitment to the space program for the fields of astronomy, atmospheric and earth sciences, engineering and physics is demonstrated. Scientists in these disciplines were the most willing to express the opinion that NASA's share of the Federal R & D budget in 1965 was about right and the least likely to feel that it should have been cut. At the same time it is clear that even within these areas a fairly widespread feeling exists that too much has gone

Table 7.
This table shows scientist's perceptions of the adequacy of support given to the total space program by scientific specialty.

	Proportion who said NASA's share of the total R & D budget in 1965:		
Disciplinary Self-identification	Should Have Been Higher	Was About Right	Should Have Been Lower
Astronomy	7%	60%	33%
Atmospheric and Earth Science	4	54	42
Biology, Life Sciences: Bio-chemistry Physics Genetics Micro-biology	4	33	63
Other	6	46	48
Chemistry	5	39	56
Engineering	5	57	38
Mathematics	0	45	52
Physics	3	45	52

into the space program as a whole. For example, fully one-third of the astronomers, almost two-fifths of the engineers (38%) and a little over half (52%) of the physicists took this view. By no means, then, are even these scientists of one mind with respect to their commitment to NASA as an organization. Does this mean that they as well as scientists in the other disciplines shown in the table want to cut back NASA's support of science or is their lack of commitment primarily aimed towards the less scientific aspects of its programs? The partial answer to this question is presented in Table 8. We shall come back to it in another fashion in the next section of the paper when we consider scientists's views on NASA's goals.

While individuals within the same or different disciplines may show considerable divergence on the issue of whether or not NASA should be continued at its present level of operation, they are virtually unanimous in their opinion that the proportion of the agency's budget devoted to the support of basic research should have been higher than it was in 1965 (approximately 1 per cent).[9] Thus though many are not particularly committed to NASA as a whole these results suggest that they are, not surprisingly perhaps, committed to the value of the support of basic research beyond its present level and presumably would wish for more resources to be devoted to this area whether or not the overall budget was reduced. In a very real fashion this is a rather paradoxical position to have taken, at least in the environment existing in the middle of the 60's. It is likely that if any such reduction had taken place it would probably have come out of the more long-run, basic research and educational rather than the manned flight programs. So, by suggesting a cut in the overall NASA budget the scientist was in fact suggesting a paring of non-mission oriented work, the very type of work, ironically, to which he seems most committed.

9. Montgomery, Op. cit., pp. 3-4.

Table 8.

This table shows scientists' perceptions of the adequacy of the support given to basic research within NASA in 1965 by scientific specialty.

Disciplinary Self-identification	Proportion who said NASA's support of basic research in 1965: Should Have Been Higher	Was About Right	Should Have Been Lower
Astronomy	91%	8%	2%
Atmospheric and Earth Science	93	6	1
Biology, Life Sciences: Bio-chemistry Physics Genetics Microbiology	94	5	1
Other	93	7	0
Chemistry	89	10	1
Engineering	88	12	0
Mathematics	96	0	4
Physics	92	8	0

From the point of view of most scientists, one of NASA's important "products" would be the research which it has made possible. The value of this product to the scientific community would depend on their evaluations of the significance of its results. Another way to get at the commitment which scientists in a given discipline feel to NASA as a unique organization is to see whether or not they believe that the research it has supported could have found alternative sources of support in the absence of the agency. In a sense, this is a test of their perceptions of the indispensability of NASA to at least a range of research done within their discipline in the past few years.

Our respondents were asked, first, to indicate the value of NASA-supported research: had it contributed to the solution of many, a few, or no basic problems in their disciplines? They were then asked to indicate whether or not they felt that this work could have received support elsewhere and what the most likely source of this support would have been. The extent to which scientists in various disciplines held the view that there would have been no likely alternative sources is another rough measure of the perceived dependence of the discipline on the space science program in NASA.

Looked at in this way, there can be little doubt that astronomers, atmospheric-earth scientists and engineers felt a dependence on NASA not shared by scientists in other disciplines. At the same time even a sizeable proportion of them - from 40 to 46 per cent - take the position that other sources of support would have been forthcoming. The mathematicians were the most extreme in their rejection of NASA. Interestingly enough they were also the group most likely to see universities or research centers (26%) as realistic alternatives. This would seem to confirm the view that mathematics, above all the other disciplines, remains a "little science." The physicists take the middle ground: they express more commitment to the space science program than mathematicians, biologists and chemists but substantially less than, say, astronomers or engineers.

Table 9.
This table shows scientists' perceptions of likely alternative sources of support for research sponsored by NASA by scientific specialty.

	Proportion selecting as likely alternative source of research support:			
Disciplinary Self-identification	No Other Source	Another Fed. Agency	University or Research Cent.	Other
Astronomy	55%	36%	5%	4%
Atmospheric and Earth Sciences	60	33	3	4
Biology, Life Sciences: Bio-chemistry Bio-physics Genetics Microbiology	32	54	9	4
Other	27	56	6	11
Chemistry	33	40	12	15
Engineering	54	35	4	7
Mathematics	22	43	26	9
Physics	41	49	5	5

Knowledge of NASA

In modern society most organizations have many different "public " and a variety of types of exchanges with these diverse publics. It is seldom that any individual or group can, in some sense, comprehend the 'totality' of any very large or complex organization. At best they have only partial knowledge of it, depending on which portion of the organization they interact with or which of its goals are most relevant to their interests. At worst they have only an over-simplified, stereotyped picture of it, a picture arising from the symbols presented in the mass media as filtered through and verified by the social network of which they are a part. We have already seen that scientists in different disciplines have a different sense of involvement in and commitment to the space science program. Do they also have a different base of knowledge from which to formulate their image of NASA?

Like any other citizen, they have been exposed to the treatments of the space program in the mass media. In addition, however, many if not most of them, by virtue of their location in the professional communication network, both formal and informal, of the scientific community have had an opportunity to gain second-hand, specialized information about and evaluations of some of the scientific activities of NASA. The real differences among scientific disciplines in terms of their knowledge base of the agency is most likely to show up with respect to their personal, informal contacts with people in the organization. Those who have had such contacts have had an opportunity to experience the agency and see its inner workings in a way quite different from those whose interaction has been limited largely to reading or hearing about its activities and goals indirectly. In one case the access has been direct and in the other second or third-hand.

This may have implications both for the image scientists have of the agency and the opportunities they enjoy for influencing its policies.

Virtually all of our respondents in astronomy (92%) report that they "know someone in the space agency well enough" to call him up and "get his informal advice on a proposal or idea" they have for research. Eighty-four per cent of the atmospheric-earth scientists and almost two-thirds of the physicists in our study (65%) also answer in the affirmative on this question. The social distance between the field of chemistry and the space program is also dramatically revealed by the figures in Table 10:

Table 10.
This table shows the extent to which scientists have personal acquaintances with NASA officials by scientific specialty.

	Proportion saying they could call someone for informal advice on a research proposal:	
Disciplinary Self-identification	Yes	No
Astronomy	92%	8%
Atmospheric-Earth Sciences	84	16
Biology, Life Sciences:		
Bio-chemistry		
Bio-physics		
Genetics		
Microbiology	36	64
Other	38	62
Chemistry	19	81
Engineering	58	42
Mathematics	30	70
Physics	65	55

less than one-fifth of the chemists report such an informal relationship. In this instance, the biologists and mathematicians come off somewhat better although their close personal contacts in the agency are in a clear minority.

Conclusion

The extent to which the respondents in our study from different disciplines have been involved in the space program may be easily grasped by looking at the summary data in Table 11. On the basis of responses to the questions discussed in this section we have rank ordered disciplines from High to Low in each of three areas: (a) the importance of space science research to the discipline; (b) the commitment of scientists in each discipline to NASA as an organization; and (c) the closeness of contact between NASA and scientists in different disciplines. There is virtually no change in the rank order position of any discipline in each of these areas. If a particular field is high in one area, it is high in the others; if it is low in one it is low in the others. Astronomy and the Atmospheric-Earth Sciences show the greatest involvement in the space science program, the collection of biological sciences - bio-chemistry, bio-physics, genetics and microbiology - and mathematics show the least with chemistry moving to the bottom of the list in the area of contact with NASA officials. Physics generally holds a middle position as do the other areas in biology and the life sciences.

Table 11.
This table shows the rank-ordering of different disciplines from High to Low in terms of (a) the centrality of the space science program; (b) the commitment to NASA and (c) personal contact with NASA.

	Centrality of Space Science	Commitment to NASA	Personal Contact with NASA
HIGH	Astronomy	Astronomy	Astronomy
	Atmos.-Earth Sci.	At.-Earth Sci.	Atmos. Earth Sci.
	Engineering	Engineering	Physics
	Physics	Physics	Engineering
	Biology, Other	Biology,Other	Biology, Other
	Chemistry	Chemistry	Bio-chem, Bio-phys, etc.
	Mathematics	Mathematics	Mathematics
LOW	Bio-chem, Bio-physics, etc.	Bio-chem, Bio-physics, etc.	Chemistry

Quite likely there is a circular relationship among the three areas of involvement. A feeling that the research made possible through the space science program is central to theoretical or methodological developments in one's field would seem, naturally, to generate a greater sense of commitment to this program. This, in turn, would probably motivate the scientist to establish or extend his personal contacts with the agency which then leads to feelings of deeper commitment and certainty that the research being done is, or should be, of significance to one's discipline. In the absence of data which could show changes over time it would be impossible to say which phase, if any, necessarily comes first.

We have not attempted here to answer the prior question of *why* scientists in some disciplines have a greater degree of involvement than others. Obviously a number of factors would be important: the composition of the decision-making structure in NASA as it bears on the initial contacts it has with different elements in the scientific community and the way in which it defines specific alternatives and scientific programs as the agency grows; the constraints imposed first by the space environment and secondly by the technology needed to get into space and the fact that some research problems are inherently easier to conduct within these constraints than others; the social composition of a given field and the particular problems which it happens to define as being worthwhile and solvable at a given point in time; the initial degree of political sophistication of a field; the greater relevance of some research for manned space flight than other research and so on. Our major interest at this point has been to establish the fact that what NASA does has greater relevance for and visibility to some elements in the scientific community than others and to identify what those elements are. This will help justify our subsequent use of the extent of involvement of different scientific fields as the major independent variable for examining how this community views and evaluates NASA and the agency's general impact upon science.

SCIENTISTS' IMAGES OF NASA: THE PROBLEM OF GOALS

The Overall Pattern

From the point of view of the scientific community, an organization like NASA is known, at least partially, by the goals which it professes. Two things stand out about the images scientists in our study have about NASA's objectives. First, the relative priorities which our respondents believe the agency has assigned to various goals are quite different from the priorities they would ideally like to see attached to them. If they had their way they would alter rather sharply the past character of the organization. At the same time, however, there is a relative lack of agreement over which of the several professed goals of the space agency have been most important in its actual operations and a relative unanimity of views about what NASA ought to be doing. Our respondents tend to divide into two camps over the question of what the major aims of the space program have been, but express a common view about what they should be. In short, wider agreement exists on values than on behavior.

A list of six general objectives for the space program was derived from the formal statements of purpose contained in the Space Act and various public remarks of scientists and government officials: (a) Exploration of the Unknown; (b) Support of the Domestic Economy; (c) Basic Research; (d) Military Security; (e) Applied Research on Aircraft, Rockets, etc.; and (f) National

Prestige. Our respondents were asked to rank order them first in terms of how important they felt they had actually been and second in terms of how important they felt they ought to be. The numbers assigned to each goal could range from 1 to 6.

Consider first the mean rank scores assigned to each goal when the scientists indicate NASA's actual objectives. Almost everyone, according to them, has been more important than Basic Research - only Support of the Domestic Economy is ranked lower.

Table 11.

This table shows the mean rank scores given by scientists to NASA's goals (a) as they are and (b) as they ought to be.

Mean Rank Scores for Goals:

Goals	As They Are	As They Ought to Be	Difference (Col.1-Col.2)
National Prestige	2.72	4.56	- 1.84
Exploration of the Unknown	3.07	2.03	+ 1.04
Applied Research	3.37	3.45	- .08
Military Security	3.47	3.71	- .24
Basic Research	3.51	2.92	+ .59
Support of Domestic Economy	4.41	4.84	- .43
(Range: High-Low)	(1.69)	(2.81)	

National Prestige heads the list with Exploration of the Unknown and Applied Research coming next. It should also be noted, however, that the differences between the mean scores for Applied Research, Military Security and Basic Research are slight. Furthermore, the range between National Prestige (2.72) and Support of the Domestic Economy (4.41) is only 1.69.

On the question of what NASA ought to be doing a different picture emerges. Our scientists would like to see it be primarily an exploratory-research oriented agency. Exploration of the Unknown has the highest mean score (2.03) and Basic Research is now second (2.92). National Prestige moves almost to the bottom of the list (4.56). There is considerably more variation in the mean rank scores assigned to each of the goals, and the range between the highest and lowest is now 2.81.

Table 12 answers the question: What proportion of the scientists in our study ranked each of the six goals as being High (1 or 2) in importance in the space program to date? A diversity of opinions is revealed by the data. They are most unanimous in rejecting Support of the Domestic Economy as an important objective in the current program in space: only 14 per cent of them placed it at the top of their list. On the other hand, only National Prestige is ranked first or second by a bare majority (54%) of these scientists. Over one-third of our respondents (35%) listed Military Security as High while an equal proportion selected Basic Research as a principle objective.

Table 12.

This table shows the proportion of scientists ranking each of the six goals High (1 or 2) in terms of their relative importance in the space program to date.

Goal	Proportion Ranking High:
National Prestige	54
Exploration of the Unknown	44
Military Security	35
Basic Research	35
Applied Research	27
Support of Domestic Economy	14

This diversity of views can be seen even more clearly when we look at the association between first and second choices. As Table 13 shows, scientists are divided in their opinion of NASA: (a) those who see it primarily as an exercise in international-military one-upsman-ship and (b) those who see it pursuing more scientific-technical objectives. For example, few who ranked National Prestige as High also did so for Basic Research (8%). They were most likely to select Military Security (34%) or Exploration of the Unknown (25%), the latter being, perhaps, the most ambiguous of the six objectives. In fact, almost one-fifth of them (17%) coupled their choice of National Prestige with Support of the Domestic Economy. For these few scientists, NASA

Table 13.

This table shows the association between first and second choice among the six goals.

Of Those Ranking High	What Proportion Also Ranked High: National Prestige	Exp. of Unknown	Basic Research	Military Security	Applied Research	Support Dom. Ec.
Nat's Prestige	X	25	8	34	20	17
Ex. of Unknown	31	X	49	9	14	3
Basic Research	13	62	X	15	13	3
Military Sec.	56	12	16	X	17	5
Applied Research	41	21	17	20	X	6
Support of Domestic Economy	64	10	7	12	11	X

appears to be a combination 'public works project' and a game of 'anything you can do I can do better'. In contrast, scientists who see the space agency as an organization engaged in Basic Research are unlikely to select National Prestige (13%) or Military Security (15%) as another major aim. Instead, a large majority (62%) rank Exploration of the Unknown - a partial synonym for basic research - as High.

Though disagreement may exist regarding what the space agency has been, scientists seem virtually of one mind about what it primarily <u>should</u> be. In ranking these same six objectives as ideal goals, three-fourths or more of them placed either Basic Research or Exploration of the Unknown at the top of their lists. Furthermore, consider the inter-relationships between first and second

Table 14.

This table shows the proportion of scientists ranking each of the six goals High (1 or 2) in terms of what they believe the objectives of NASA ought to be.

Goal	Proportion Ranking High:
Basic Research	78
Exploration of the Unknown	75
Military Security	23
Applied Research	18
National Prestige	8
Support of Domestic Economy	6

choices. Virtually all (78%) who ranked Basic Research High also gave a similar ranking to the Exploration of the Unknwon. Their negative feelings towards National Prestige as a highly desirable goal can be seen from the figures in Table 14. Even Military Security is viewed as a more legitimate major objective by a higher proportion of our respondants (23%) than National Prestige (8%). Clearly if the scientists in our study had their way they would alter rather drastically the character and major direction of NASA in the recent past.

Involvement and Goals

A scientist in the disciplines of Astronomy, Atmospheric-Earth Sciences, Engineering or Physics, which as we have seen, is relatively highly involved in the space sciences program, tends to weight the importance of actual NASA goals rather differently from a scientist in the less committed disciplines - Biology and the Life Sciences, Chemistry and Mathematics. A scientist in the former disciplines appears more sceptical of what NASA has been doing: National Prestige and Support of the Domestic Economy seem to bulk larger for him as aims of the past than they do for his colleague in the less committed fields, although he also gives more relative weight to Basic Research than he does. In addition, Exploration of the Unknown seems a more legiti ate ideal goal to him, perhaps, because it lacks the more specific operational or emotional connotations of some of the other goals. A scientist in an area with less immediacy to space not only places greater stress on Basic Research as an ideal goal but is also more able to tolerate the notion of Military Security as a legitimate aim in the space program. In spite of such nuances, however, it is still apparent that, overall, there is still greater agreement on what NASA ought to be doing than on what it has been doing. A scientist's position relative to the space science program makes more of a difference in his perceptions of behavior than it does in his values. Let us consider these similarities and differences in more detail.

Those closest to the program give a higher mean rank score to National Prestige (2.53) and Support of the Domestic Economy

Table 15.

This table shows the mean rank scores given by scientists to NASA's goals (a) as they are, by involvement of discipline in space program.

Goals	Mean Rank Scores for Goals as they are for scientists in: Most Involved Disciplines[1] Scores (1)	Most Involved Disciplines[1] Rank Order (2)	Less Involved Disciplines[2] Scores (3)	Less Involved Disciplines[2] Rank Order (4)	Differences (Col 1-Col 3) (5)
National Prestige	2.53	1	2.92	1	- .39
Exploration of the Unknown	3.05	2	3.09	2	- .04
Basic Research	3.46	3	3.60	5	- .14
Applied Research	3.61	4	3.15	3	+ .46
Military Security	3.77	5	3.16	4	+ .61
Support of Domestic Economy	4.19	6	4.63	6	- .44

1. Astronomy, Atmospheric-Earth Sciences, Engineering, Physics
2. Biology, Chemistry, Mathematics

(4.19) as actual goals than do those more remote from it (2.92 and 4.63). The latter group ranks Military Security and Applied Research considerably higher than do the former. However, these goals, as we say in the last section, are considered more legitimate for NASA than either National Prestige or Support of the Domestic Economy. On the issue of Basic Research, there is little difference (-.14) between the two groups in the mean rank scores, though those in less committed disciplines score it somewhat lower. When we look at the relative rankings within each group, however, (Cols. 2 and 4 in Table 15) Basic Research assumes a different position. Scientists in areas most involved in space work rank it third in importance. Scientists outside the program place it fifth; only Support of the Domestic Economy is, on the average, ranked lower by them.

The same relationships can be seen when we compare the proportions of scientists in the committed disciplines ranking each actual goal High (1 or 2) with those in the less committed areas.

Table 16.

This table shows the proportion of scientists ranking actual goals High (1 or 2) by involvement of discipline in space sciences program.

	Proportion Ranking Goals High when involvement of discipline is:				
	High		Low		
Goals	% (1)	Rank Order (2)	% (3)	Rank Order (4)	Difference (Col 1-Col 3)
National Prestige	59	1	51	1	+8[1]
Exploration of the Unknown	45	2	47	2	-2
Basic Research	36	3	35	4	+1
Military Security	28	4	39	3	-11[1]
Applied Research	23	5	32	5	-9[1]
Support of Domestic Economy	19	6	11	6	+8[1]

1. $X^2 = 21.52$, $P < .001$

National Prestige and Support of the Domestic Economy are ranked High significantly more often by those in the more involved than by those in the less involved groups. The latter scientists, in contrast, give substantially more emphasis to Military Security and Applied Research. If we assign rank orders on the basis of proportions selecting each of the goals as High (Cols. 2 and 4 in Table 16) we see, again, that there is a reversal in the position of Basic Research. Relative to the other objectives, those in disciplines less dependent on NASA are less prone to place it at the top of their list as an actual goal.

Table 17.

This table shows the mean rank scores given by scientists to NASA's goals (b) as they ought to be, by involvement of discipline in space program.

	Mean Rank Scores for Goals as they are for scientists in:				
	Most Involved Disciplines[1]		Less Involved Disciplines[2]		Differences
	Scores	Rank Order	Scores	Rank Order	(Col 1-Col 3)
Goals	(1)	(2)	(3)	(4)	(5)
Exploration of the Unknown	1.92	1	2.09	1	- .17
Basic Research	2.15	2	2.14	2	+ .01
Applied Research	3.56	3	3.36	3	+ .20
Military Security	3.93	4	3.48	4	+ .45
National Prestige	4.38	5	4.72	5	- .34
Support of the Domestic Economy	4.74	6	4.96	6	- .22

1. Astronomy, Atmospheric-Earth Sciences, Engineering, Physics
2. Biology, Chemistry, Mathematics

Regarding the question of values, the extent to which a scientist's discipline is involved in the space sciences program seems to have little impact on his perceptions of what NASA ought to be doing. On the basis of the mean rank scores, the rank ordering of the six goals is identical: Exploration of the Unknown and Basic Research are first and second, National Prestige and Support of the Domestic Economy are fifth and sixth and Applied Research and Military Security fall in the middle. All agree on the relative importance of the various objectives.

The greatest single difference revolves around the relative importance of Military Security as an ideal goal. As Table 17 shows, those with a low involvement in space work assign it a higher mean rank score (3.48) than those in the more involved areas (3.93). This same difference shows up when we compare the proportion of scientists in the two groups ranking each of the ideal goals High (1 or 2). Those with little investment in space research are significantly more likely to see Military Security as a legitimate goal (27%) than those more directly concerned with such research. A higher proportion of this latter group (78%) favors Exploration of the Unknown more frequently as an ideally important objective than scientists in the less involved disciplines. Another interesting item emerges from the data in Table 18. When the goals are rank ordered on the basis of the proportions of scientists selecting them as highly important, Basic Research is first and Exploration of the Unknown second for those outside of the space program while the order is reversed for those more on the inside.

Table 18.

This table shows the proportion of scientists ranking ideal goals High (1 or 2) by involvement of discipline in space sciences program.

	Proportion Ranking Goals High when Involvement of Discipline is:				
	High		Low		Difference (Col 1-Col 3)
Goals	%	Rank Order	%	Rank Order	
Exploration of the Unknown	78	1	71	2	+ 7[1]
Basic Research	75	2	76	1	- 1
Military Security	19	3	27	3	- 8[2]
Applied Research	17	4	20	4	- 3
National Prestige	10	5	8	5	+ 2
Support of the Domestic Economy	7	6	5	6	+ 2

1. $X^2 = 7.08$, .05 P .01

2. $X^2 = 23.98$, P .001

IDEAL AND REALITY: SOURCES OF DISSATISFACTION

One indication of the degree of satisfaction of an individual or group with a policy or institution is the extent of congruence between their perceptions of what is and what ought to be. Where, for whatever antecedent reasons, a group expects an organization to pursue certain highly important values and yet feels that these expectations are not being fully met, this discrepancy represents a source of dissatisfaction with the organization and its policies.

This certainly proves to be the case with many of the scientists in our study. As we have already seen, over three-fourths of them felt that Basic Research ought to be a central value in NASA. Yet of this group, less than half (41%) feel that this has

Table 19.

This table shows the association between the ideal importance of Basic Research as a goal in NASA and the actual importance of it to date.

Of Those Ranking Basic Research Ideally:	What Proportion Rank it Actually:		
	High	Medium	Low
High	41	27	33
(Satisfaction)	(Satisfied)		(Disatisfied)

actually been the case while one-third take the position that research has received a low priority relative to other goals. The remainder rank Basic Research as Medium (3 or 4) in importance. By comparing those who see a close congruence between practice and ideal (High-High) with those seeing a low congruence (High-Low), one can see how dissatisfaction with NASA's overall goals spills over into other judgments about the agency and its performance.

Scientists dissatisfied with NASA as a research-oriented agency clearly could not be counted on as a source of support within the scientific community for enlarging the agency's non-research oriented programs beyond their present level. In fact,

Table 20.

This table shows the association between satisfaction with NASA as a research-oriented agency and attitudes towards the adequacy of support for NASA in 1965.

	Proportion who said NASA's share of total R & D budget in 1965:		
Satisfaction	Should Have Been Higher	Was About Right	Should Have Been Lower
High	7	55	36
Low	1	33	66

$X^2 = 43.84$, $P > .001$

if these individuals had their way, they would reduce the overall NASA budget but at the same time the proportion of the total budget devoted to basic research and to work within their own areas of interest. In these latter respects, they are like scientists more enamored with NASA's scientific efforts to date. That is, regardless of satisfaction, most (Satisfied: 91%, Dissatisfied: 95%) would want to see more resources within the agency diverted to research and a majority (Satisfied: 54%, Dissatisfied: 61%) believe their discipline's share of the NASA pie should be increased. However, two-thirds of those dissatisfied with NASA's emphasis on research also felt that its budget should have been cut in 1965. Only a little over one-third (36%) of the more satisfied took this position and 7 per cent of them went so far as to say that the space agency should have received even more than it did.

A scientist's evaluations of the quality of actual research output under NASA auspices is also affected by his satisfaction with the agency. In addition to its own in-house work, through its funding of project-type research as well as its Sustaining University Program, the agency has made possible a great deal of research in numerous universities and research centers. How good has that work been to date in terms of its contributions to the solution of some basic problems in various fields? While many of our scientists express some reservations on this score, the

Table 21.

This table shows the association between satisfaction with NASA as a research-oriented agency and evaluations scientists make of the contributions of NASA-supported research to the solution of basic problems in their disciplines.

	Proportion who say there have been:		
Satisfaction	Many Contributions	Few Contributions	No Contributions
High	26	49	25
Low	14	50	36

$X^2 = 15.01 \quad P < .001$

scepticism is most notable among those who are dissatisfied with NASA. Few of them (14%) believe that this work has been of much basic value and over one-third (36%) feel that nothing significant has been forthcoming.

This scepticism is even more pronounced in their evaluations of the scientific payoff from space flight experiments. Our respondents were asked: "In terms of their potential contributions to the solution of some basic, unsolved scientific problems in your field, how would you rate the overall quality of the space flight experiments (on orbiting satellites, orbiting observatories, etc.) conducted to date?" Almost three fourths (71%) of the dissatisfied scientists felt that this work has been of negligible quality, though a small number (7%) saw considerable value in it. Even among the more satisfied, as can be seen from Table 22, there

Table 22.

This table shows the association between satisfaction with NASA as a research-oriented agency and evaluations scientists make of the scientific value of space flight experiments to their various disciplines.

Satisfaction	Most of High Quality	Many of High Quality	Few or None of High Quality
High	19	40	41
Low	7	22	71

$X^2 = 44.96 \quad P < .001$

were reservations about these efforts with 41 per cent of this group voicing negative evaluations. As we shall see still more clearly in the next section, many scientists apparently question seriously the contributions to knowledge from space flight work, but most especially this is true for those who see NASA deviating sharply from the ideal of Basic Research as a major goal.

Who are these dissatisfied scientists? What is at the root of their dissatisfaction, their feeling that the highly important objective of basic research is presently being slighted by NASA? One possibility is that involvement in the space program is an important ingredient of their pessimism. That is, it may be that those scientists who are most dissatisfied also tend to come from disciplines which have little or no commitment to, or knowledge of the agency. Being on the outside, so to speak, they are able to maintain the 'purity' of their abstract commitment to basic research and their disdain for what NASA has been doing. In contrast, those who have a vested interest in space have little choice but to insist that what NASA does is, in large part, oriented towards basic problems. In this fashion they justify their connection with the program.

Unfortunately the data does not support this reasonable hypothesis. Whether one looks at scientific discipline or sample population (NASA, Space Scientists, National Academy of Science, American Men of Science) there are no differences between the two groups. Those who are satisfied are as likely to come from within NASA, for example, or to be Astronomers or Chemists as those who are dissatisfied. Clearly involvement in the space program or lack of it, at least as measured by these crude indicators, is not related to whether or not a scientist feels there is a lack of congruence between what NASA ought to be doing and is doing with respect to basic research.

Do scientists engaged primarily in basic research and teaching tend to be those who are most dissatisfied with NASA while those in managerial positions or engaged in development and applied research predominate in the more satisfied group? It may well be that a scientist's occupation determines his perceptions of NASA's goals, since managers may have rather different values or different types of access to what the space agency is pursuing than scientists in basic research and teaching. If this is the case, in our instance it has no appreciable bearing on an individual's satisfaction with NASA. Almost an equal proportion of managers and researchers - basic and applied - is in both the more and less satisfied group. The explanation still lies elsewhere.

One possible clue comes from some of the research on the satisfaction of workers and managers in government and industry. Time and again, studies have demonstrated that satisfaction is correlated with the opportunity a worker or supervisor feels he has to influence his own destiny, so to speak, to have a hand in shaping the programs and policies which have some direct affect on him. His satisfaction is highest when he expects to have a chance to communicate his views on matters to those above him and finds both that these expectations are met and that his communications have some demonstrable affect on what is done.

This, indeed, appears to be the case with the scientists in our study. Dissatisfaction and a feeling of alienation from the decision-making structure in NASA go hand in hand. Among the more dissatisfied there is a widespread feeling that the scientific community should have more influence than at present on the general direction of the space program. Over four-fifths (82%) of them express this view. A substantial though significantly small number (60%) of the more satisfied scientists take this position. However, when they do so, it is with a crucial difference.

When the latter group says that it expects to have more influence it is doing so in a situation in which it believes that the scientific community already has had a substantial say in the overall composition of the space program. In other words, they are starting from a different perception of reality than the less satisfied. They are saying, in effect, that they want more influence on decision-making for the scientific community

Table 23.

This table shows the amount of influence scientists believe the scientific community has had on the overall direction of the space program by degree of satisfaction with NASA and amount of expected influence.

		Proportion who say Scientific Community has had a:		
Satisfaction	Expected Influence	Great Deal Of Influence	Some Influence	Little or No Influence
High	More	21	49	30
	About Right	43	49	8
Low	More	5	33	60
	About Right	32	55	13

while recognizing that it has already had a considerable amount. In contrast, as Table 23 shows, scientists who are less satisfied with NASA and desire a larger role for the scientific community in the shaping of the space program are starting from a different base point. Most of them (60%) apparently detect little or no influence of the scientific community in the present direction of the overall program. For them there is a considerable discrepancy between their expectations and what has been realized. They feel that scientists have been left out and ought to be in. The elaborate network and variety of NASA scientific advisory committees and occasional scientific testimony before Congress is apparently either unknown to them or, more likely, unpersuasive in terms of its actual effect on the direction of the space program when they think it ought to be. This situation contributes to their dissatisfaction with NASA as a research-oriented agency.

SCIENTIST'S IMAGES OF NASA: THE SCIENTIFIC PAYOFF

The Overall Pattern

While the goals which an organization like NASA professes are an important ingredient of the image it projects to and the relationships it has with the scientific community, this is by no means the entire story. By definition an organization, like any system, has some output - in terms of service, values, or material objects - which groups or other organizations in its environment stand ready to accept at some "price".

From the political system NASA has received certain inputs in the form of power and capital which it, in turn, has used in alternative ways, including the creation of a distinctive technology and the support of certain research projects and researchers to the exclusion of others. It has also received, both from the political system and from the scientific community, inputs in the form of demands or expectations as to how it is to use these resources. Thus it's allocative decisions have not been made in a vacuum. They may be thought of as representing, at least in part, an attempt to respond to these external demands with the knowledge that the failure to do so would jeopardize the receipt of future inputs and thus the survival of the organization itself. For the scientific community, NASA's output is, ultimately, a normative value: the results of the research and the technology which it has made possible. Its value can be determined only in relation to its consequences for the system of science - its normative and social structure, its cognitive apparatus.

On the whole, the scientist in our study are generous in their evaluation of the results of NASA's scientific and technological efforts to date though there are, as might be expected from the previous findings, a sizeable number who view them with mixed feelings if not outright antipathy. Take the question of or not the research it has supported has led to the solution of

Table 24.

This table shows scientist's evaluations of the contributions of NASA-supported research to the solution of basic problems in various scientific disciplines.

Proportion who said there had been:

Many Contributions	A Few Contributions	No Contributions
20%	47%	33%

some basic, previously unsolved problems in various disciplines. When asked to judge the agency's efforts by this rather rigorous standard, fully one-fifth of our respondents felt that there had been many payoffs of value. Almost another half of them (47%) were able to see at least a few results of some worth and only one-third felt that there had been no scientific payoff whatsoever.

The distribution of responses was similar when we requested an evaluation of the overall quality of space flight experiments by this same criterion. Fourteen per cent of these scientists felt that all experiments had been of high quality and another 30 per cent took the view that at least a majority had been so. Less than one-third (29%) felt that nothing significant had come from them to date.

There is also little doubt about the effects of space technology *per se* on the conduct of scientific inquiry in various fields. Most (77%) of our respondents report at least some impact of space technology on research though it was felt to be

Table 25.

This table shows scientist's evaluations of the quality of space flight experiments in terms of their potential contribution to the solution of basic problems in various scientific disciplines.

Proportion who said that:

Most Were of High Quality	Many Were of High Quality	Few Were of High Quality	None Were of High Quality
14 %	30 %	27 %	29%

more quantitative than qualitative. Among this group, a majority (52%) would characterize the effect simply in terms of an increase in the amount of data to be processed and over one-third (35%) would add that it has heightened the complexity of the research process - the number of people and the amount of paperwork involved - a great deal. The numbers seeing comparable qualitative shifts in research are considerably smaller. At the same time, however, the table points up the fact that all but a relative handful see at least <u>some</u> qualitative benefit to their discipline from the technology of space.

Table 26.

This table shows scientist's perceptions of the impact of space science technology on research.

	Proportion who see them affected:		
Areas of Research Affected by Technology	Great Deal	Some	None
Increase in quantity of data	52%	40%	7%
Increase in complexity of research process	35	47	18
Increase in quality of research done	28	57	16
Change in types of problems studied	29	61	10

Involvement and Scientific Payoff

While we may talk of the 'scientific community' as if it were a single, fairly homogenous group of individuals sharing similar values, perspectives, and conceptual frameworks, it is in reality a collection of groups divided by differences in methodology, substantive and theoretical concerns and institutional identifications as well as by differences in status and power in the wider, non-scientific community. Perhaps the major thing scientists have in common aside from the name itself which is not an unimportant matter, of course, is a kind of very general belief that man and his environment can be studied according to certain rational rules of procedure and that some sort of organized cognitive understanding of these subjects will be the result. We have already seen that one way in which this scientific community may be differentiated is in terms of the dependance of its various sub groups on the space program, and we have examined the consequences of this differentiation for images of NASA's goals. This differentiation has an even sharper effect when we turn to the question of the value which scientists place on the results of the agency's scientific activities. Those in disciplines most intimately involved with the space program place a greater value on them than do those in areas that have had little or no contact with it. According to our respondents, in disciplines closely connected to space science the results of NASA's program have proven to be of substantial scientific benefit. At the same time, little spill-over of this benefit has taken place outside of these disciplines into areas like biology, chemistry and mathematics which are more on the poriphera of the program.

Specifically, for example, has the research supported by the agency paid off for science? It all depends on who you ask. Almost one-third (31%) of those in NASA-related disciplines believe it has - and quite handsomely. Less than one-tenth (7%) of those in the other disciplines take this position and, in fact, almost half of them (49%) see no value at all to their discipline from the NASA-supported scientific work. While they are a bit more generous in their evaluations of the benefit which might be

Table 27.

This table shows scientist's evaluations of the contributions of NASA-supported research to the solution of basic problems in various scientific disciplines by involvement of discipline in space program.

Proportion who said there had been:

Involvement of Discipline	Many Contributions	A Few Contributions	No Contributions
High[1]	31%	52%	17%
Low[2]	7	44	49

1. Astronomy, Atmospheric-Earth Sciences, Engineering, Physics
2. Biology, Chemistry, Mathematics

$X^2 = 174.96, \quad P < .001$

Table 28.

This table shows scientist's evaluations of the quality of space flight experiments in terms of their potential contribution to the solution of basic problems in various scientific disciplines by involvement of disciplines in the space program.

Proportion who said that:

Involvement of Discipline	Most, Many of High Quality	Few of High Quality	None of High Quality
High	60%	28%	12%
Low	27	27	47

$X^2 = 174.84, \quad P < .001$

realized from space flight experiments - 27 per cent of them feel that much of this work is of substantial quality - a large proportion (47%) remain highly dubious, at least from the viewpoint of their discipline. This is in marked contrast to those more involved in space research as Table 28 demonstrates. For a majority of them (60%), most, if not all, of these experiments have been well conceived and conducted. This, of course, might be expected since many of them have been the very individuals conducting these experiments.

What about the impact of space technology on the conduct of research itself? Again, it depends on who is giving the answer.

Table 29.

This table shows the proportion of scientists who see a substantial impact of space technology on different aspects of the research process by the involvement of disciplines in the space program.

Proportion who say there has been a substantial:	Involvement of Discipline: High	Involvement of Discipline: Low
Increase in complexity	45%	19%
Increase in Quantity of data	64	35
Change in kinds of problems studied	39	13
Improvement in Quality of data	37	15

If a scientist is in a NASA-related discipline the chances are very good that he not only will believe that the impact has been considerable but that he will also describe it largely in quantitative terms. From where he stands, space technology has increased the quantity of data to be dealt with and the complexity of research itself more than it has improved the quality of data available or changed the kinds of problems which he can study. A scientist in an area outside of the NASA orbit isn't very likely to believe that its technological apparatus has had much effect on his activities. However, when it has, it apparently has also been of a more quantitative nature.

Do those who stress the quantitative aspects of NASA's impact on scientific inquiry limit themselves to this alone or do at least some of them admit to the qualitative benefits of this technology as well? In order to answer this question we divided our respondents into three groups: (a) those who stress only the qualitative impact; (b) those who stress only the quantitative impact, and (c) those who stress some mixture of both. An inspection of Table 30 reveals the results. Most scientists fall in the third category. It is also clear, however, that those in areas most involved in the space program favor quantity over quality: only 8 per cent of them stress quality alone while 34 per cent single out quantity. Scientists whose disciplines are less involved also stress quantity over quality but they are

Table 30.

This table shows scientists perceptions of the impact of space technology on research by involvement of discipline.

Proportion who stress:

Involvement of Discipline	Quality Only	Quantity Only	Both Quality and Quantity
High	8%	34%	58%
Low	13	24	63

$X^2 = 7.00 \quad .05 \quad P \quad .01$

significantly less likely to do so. A higher proportion of them (13%) feel that NASA's technology has improved or at least had a mixed impact (63%) on research in the field. Less than one-quarter (24%) single out the quantitative effects alone.

This finding suggests that one of the prices paid by scientists in such areas as physics or astronomy for their greater involvement in and benefit from the space program is a rather sizeable increase in the sheer complexity and difficulty of the organization of research. The potential scientific payoff of space flight experiments for example, may be very high but participation in them is not without cost, cost in the form of increased red-tape, administrative work, coordination of more and more specialists, and the sheer amount of data to be collected, stored, and digested. The mathematician, microbiologist, or organic chemist may not see much of scientific value accruing to him by virtue of NASA's scientific efforts. When it does, however, it is apparently less frequently accompanied by such costs or else the costs and benefits - opportunity to work on different kinds of problems or collect better data - seem to balance themselves out.

Why this might be the case is not clear from the present analysis. One possibility which suggests itself, however, is that it is easier for scientists in a discipline lacking direct involvement in NASA's activities to see either nothing of value or primarily only those things of value. They either know little or nothing of the program or know primarily of some of its benefits. Those in areas with a first hand acquaintance of the agency's efforts have a somewhat more balanced and, in a very real sense, more realistic perspective. They see much of the space program is good but they also have been in a position to experience first hand many of the problems and difficulties of space research.

Personal Interests and Scientific Payoff

It might well be that what we have been calling the effects of disciplinary involvement in the space program on a scientist's evaluations of NASA's scientific activities is really a reflection of his personal relationship to the program. Those who work for the agency or who have received grants from it, participated in flight experiments or served as advisors have had a direct, personal experience with it over and above the question of their particular discipline. This element of personal contact is much less likely for individuals whose names were drawn at random from a national listing of scientists in the United States. By virtue of their status in the scientific community and their formal relation with government, members of the National Academy of Sciences (NAS) are more likely to have had some personal experience with NASA but they too are in a position different from those working there, advising it, or using its money and technology for research.

Table 31.

This table shows sample population by involvement of discipline in space science program.

	SPACE SCIENTISTS		OTHER SCIENTISTS	
Discipline Involvement	NASA	Other Sp. Scientists	Nat'l Ac. of Science	Amer. Men of Science
High	18%	48%	3%	32%
Low	2	16	14	67

A majority of those in NASA-related disciplines also happen to be either NASA employees (18%) or from our sample of space scientists (48%)[10]. As we have seen, it is also this group which evaluates the agency's scientific efforts most highly. In contrast, most of the scientists in the biological-life sciences, chemistry and mathematics

10. For a description of this sample and the population from which it was drawn, see above.

are in our sample drawn from American Men of Science (67%) or the National Academy of Science (14%). They in turn, are the disciplines which see the least benefit from NASA-supported research and space flight experiments. What happens, then, to the original relationship between disciplinary involvement and evaluation of NASA's activities when this element of personal interest is taken into account? The question is partially answered in Table 32.

Table 32.

This table examines the effect of personal experience with the space program (Space Scientists vs. Others) on the relation between disciplinary involvement and evaluations of NASA's scientific activities.

	SPACE SCIENTISTS			OTHER SCIENTISTS		
Proportion saying:	Discipline Involvement			Discipline Involvement		
	High	Low	Diff.	High	Low	Diff.
Space Tech. had great impact on research in field	56%	14%	42%	22%	8%	14%
Most Flt. expmts. of high quality	66	32	34	47	25	22
Many basic cont. from NASA-supported research	41	8	33	10	7	3

Discipline continues to be the decisive factor, most especially among Space Scientists. Consider, first, the evaluations made by these Space Scientists. Those in areas like astronomy, physics and engineering are much more likely than those in biology or chemistry to evaluate highly the potential scientific benefits flowing from NASA-supported research and space flight experiments. They are also the most likely to believe that space technology has had an impact on research in their field. In fact, the differences between the two groups are greatest at this point.

Now examine the responses of scientists from our AMS or NAS samples. The magnitude of difference between those in more and in less involved disciplines is substantially less but they are consistently in the same direction. Those in the most involved disciplines evaluate NASA efforts more favorably and the impact of its technology greater than scientists in less committed areas.

Looking at the table as a whole, it can be seen that the most enthusiastic scientists are those who have been both personally _and_, as members of a particular discipline, professionally affected by the space program. Scientists whose disciplines have a stake in the program but who have not personally had contact with it are next in being generous in their evaluations. Those with neither a personal nor a scientific commitment are consistently the least likely to express positive views on its contributions to science or to see its technology as affecting scientific inquiry in their research.

It also seems that personal involvement in the space program by _itself_ is not enough to have an appreciable effect on a scientist's positive opinions of NASA's activities. Only when he is also in a

Table 33.

This table shows that personal experience accounts for less of the differences among scientists in their evaluations of NASA's scientific activities than disciplinary involvement.

	HIGH DISCIPLINE INVOLVEMENT			LOW DISCIPLINE INVOLVEMENT		
Proportion Saying:	Space Scientists	Other Scientists	Diff.	Space Scientists	Other Scientists	Diff.
Space Tech. had great impact on research in field	56%	22%	34%	14%	8%	6%
Most flt. experiments of high quality	66	47	19	32	25	7
Many basic contributions from NASA-supported research	41	10	31	8	7	1

discipline which is closely associated with the space program does personal involvement have such an effect on his views and then the effect is substantial as Table 33 shows. If he is not in such a field, it makes significantly less difference. His evaluations are almost identical with those of his colleagues who have had little or no personal contact with the program. In short, a scientist's positive evaluations of the potential scientific payoff from NASA-supported activities increases, first as his discipline as a whole is drawn into the program and, secondly, as he has some direct,

Table 34.

This table examines the effect of personal experience with the space program (Space Scientists vs. Others) on the relation between disciplinary involvement and evaluations of the impact of space science technology on the conduct of research in different disciplines.

	SPACE SCIENTISTS		OTHER SCIENTISTS	
	Discipline Involv.		Discipline Involv.	
	High	Low	High	Low
% saying space technology had great impact on research in their field	56%	14%	22%	8%
Proportion who stresed:				
Qualitative impact along	6	9	14	15
Quantitative impact alone	31	26	45	21

personal experience with the agency's program.

If the benefit of participation appears great, so, apparently, do some of the costs. In reporting that space technology has affected the conduct of research a scientist in a field closely aligned to the space program is more likely to be talking about quantity rather than quality of research results in his field. This statement is even more true for the scientist who has also had some personal contact with the program. NASA-supported research has paid off handsomely and, at the same time, its technology has had a considerable impact on his work or that of others. It has increased substantially the whole series of interrelationships he must have with others and the amount of time he must spend communicating with and coordinating his own and the activities of others.

If he has had little or no contact with NASA, either in a personal or professional sense, he is, as we have seen, unlikely to report much scientific payoff from the work it has made possible. Neither does he think that space technology has affected what people in his field are doing. In those few instances where he believes it has, however, he is much more likely than anyone else to emphasize the quality and play down quantity of the results of space research. It has changed the kinds of problems which people in his discipline can work on and improved the quality of data available to them. For him - the biologist or chemist, say, who has had little direct contact with NASA if any - the gains, such as they are, appear to have been achieved at less cost than is the case for others.

SCIENTISTS IMAGES OF NASA: DECISION-MAKING AND THE PROBLEM OF INFLUENCE

The National Aeronautics and Space Act of 1958 assigned to NASA the explicit goal of expanding "...human knowledge of phenomena in the atmosphere and space."[11] In the pursuit of this objective the agency has created, sometimes by itself, sometimes

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11. op. cit.

jointly with other agencies like the National Academy of Science, a proliferation of advisory and study committees to provide it with guidance and information on and evaluations of alternative scientific programs. In-house scientists and engineers, both at the field center and headquarters levels, have likewise had some role in decision-making within the agency and numerous grants and contracts have been let to universities and private industry for the purpose of studying and recommending various scientific undertakings. All of these inputs presumably have some effect on the space program as a whole and on the shape of its scientific efforts in particular. Certainly when agency officials

Table 35.

This table shows the relation between perceived influence in the space program and involvement of scientific discipline.

	Proportion who said scientists have had:		
Involvement of Discipline	Great Deal of Influence	Some Influence	Little or No Influence
	22%	45%	33%
High	59	54	36
Low	41	46	64

$X^2 = 38.88 \quad P < .001$

testify before Congress, claiming that their programs have been shaped on the basis of advice from many first-rate scientists is used as a major way for legitimating and justifying their content and the priorities assigned to various ones. If these officials are to be believed, scientists have had a major say in what is being done and how it is being done.

What do scientists themselves say? How much influence do they believe they have had on either the general direction of the space program or that specific segment of interest to them? Few of those in our study (22%) were apparently as convinced, as at least, some agency officials are, that scientists have had a great deal to say about the outline of the total program. A majority expressing this opinion (59%) were in NASA-related disciplines. The view that real scientific input had been miniscule, at best, was more widespread (33%), especially among those in disciplines outside of the NASA orbit (64%).

Even within the more narrow confines of the space science program itself less than one-third (29%) of our respondents were willing to go so far as to say that scientists had had a major influence on this program. An equal proportion saw little evidence whatsoever of scientific influence. On this question, however, the differences among scientists in the more and less committed disciplines was particularly sharp. Three-fourths of those claiming great influence for science were in areas like astronomy, physics, and engineering. Conversely, three-fourths of those seeing a minimal scientific input were in the bio-sciences, chemistry or mathematics.

Table 36.

This table shows the relation between perceived influence in the space science program and involvement of scientific discipline.

Proportion who said scientists have had:

Involvement of Discipline	Great Deal of Influence	Some Influence	Little or No Influence
	29%	42%	29%
High	74	48	25
Low	26	52	75

$X^2 = 160.65, \quad P < .001$

In fact, as the data in Table 37 shows, scientists in the less involved disciplines were more likely to detect some substantial scientific influence on the space program as a whole (18%)

Table 37.

This table looks at perceived influence in (a) the total space program and (b) the space sciences program by involvement of discipline.

Proportion who say scientists have had:

	Great Deal of Influence		Some Influence		Little or No Influence	
Involvement of Discipline	Total Program	Sp. Sci. Program	Total Program	S.S. Pro.	Total Program	S.S. Program
High	26%	42%	49%	42%	24%	16%
Low	18	14	40	42	42	44

than they were within their particular area of interest in NASA's science program <u>per se</u> (14%). The opposite is even more clearly the case for those in more involved disciplines. The closer they get to home, so to speak, the more of a hand they believe the scientific community, or at least that segment of most concern to them, has had in influencing the agency's programs.

The physicist or, say, the astronomer in our study, then, takes the position that there has been considerable scientific input to NASA, that the community of scientists has had at least some influence on its programs, most especially on those closest to his own field. The perspective of the biologist or chemist is quite different. He is much less likely to see the 'hand of science' in anything NASA has done, either in general or in those areas of the space science program of most potential interest to him. To the extent that he does believe that his colleagues have had some say, it is most in evidence, for him, in the general direction of the total program.

How Much Influence Should Scientists Have?

A majority of all of our scientists want *more* influence for the scientific community in the general direction of the space program, and almost as many want to increase their voice in the space sciences program as well. Almost no one is for reducing the input from science. Furthermore, the less influence a scientist believes that he and his colleagues have had to date, especially on the general space program, the more he feels they ought to have. This is true regardless of how closely involved his discipline has been with NASA. Those who feel on the outside, in terms of influence, want in; those who feel in, in this regard, are pretty well satisfied with things.

Table 38.

This table shows the association between the desire for influence on decision-making in the space program and involvement of scientific discipline.

	Proportion who said scientists should have:			
Involvement of Discipline	More Influence	Things About Right	Less Influence	Don't Know
	54%	31%	2%	13%
High	46	53	62	37
Low	54	47	38	63

$X^2 = 10.38, \quad .05 \langle P \rangle .01$

Consider first the responses to the question: "Do you think the scientific community should have more or less say in the direction of the nation's space program or have things been about right as they are?" A majority (54%) want a bigger voice for science. This group, as Table 38 demonstrates, was about evenly divided between those in more involved (46%) and less involved (54%) disciplines. To the extent that there was doubt on this issue (13%), it was concentrated among the latter group (63%)

while over three-fifths (62%) of the handful of our respondents indicating a desire to decrease the influence of scientists were in the NASA-related disciplines.

Now examine the distribution of responses to a similarly worded question related to the "space science program in your field of scientific interest." The proportion wanting more influence decreases (44%), while the proportion satisfied with

Table 39.

This table shows the association between the desire for influence on decision-making in the space sciences program and involvement of scientific discipline.

	Proportion who said scientists should have:			
Involvement of Discipline	More Influence	Things About Right	Less Influence	Don't Know
	44%	43%	0.8%	12%
High	46	53	90	31
Low	54	47	10	69

$X^2 = 28.23, \quad P < .001$

things as they stand increases to 43 per cent. Again, those wanting more influence are about equally divided among those in more (46%) and less (54%) involved disciplines. The proportion of those wishing to reduce the role of scientists drops to less than 1 per cent of the total. Most of those who are undecided (69%) remain in areas on the poriphera of the space program. It is also clear from both of the above tables that scientists whose disciplines are removed from this program are the most likely to be seeking a greater role for scientists in decision-making in the agency.

The meaning of this association between disciplinary involvement and the desire for a greater say in policy-making is examined further in the next two tables. What they show is that the amount of influence which a scientist believes the scientific community has already had shapes his beliefs about how much he thinks they should have. If he thinks there has already been a significant input from science, then he is generally satisfied. He thinks that 'things are about right' as they are. If he believes that scientists have had little or no opportunity to influence decisions, he is unhappy, especially in the area of the general direction of the space program as a whole. He finds a discrepancy between what is and what ought to be, from his point of view, and wants more of a say for himself and his colleagues. The fact (Table 37 above) that our respondents in fields like biology, chemistry, and mathematics are most likely believers that the participation of scientists in decision-making has been very limited, helps account for some of the association, in turn, between disciplinary involvement and perceptions of how much influence scientists should have.

Look first, then, at Table 40. An inspection of the data reveals several things. First, the proportion of our respondents expressing a desire to have a larger role for science increases

Table 40.

This table shows scientist's perceptions of how much influence they should have on the total space program by discipline involvement and perceptions of actual influence.

	Involvement of Discipline			
	HIGH % who say scientists should have:		LOW % who say scientists should have:	
Actual Influence of Scientists in Total Space Program	More Influence	Things About Right	More Influence	Things About Right
Great Deal	27%		18%	
	29%	62%	34%	56%
Some	49		40	
	59	32	55	34
Very Little, None	24		42	
	70	15	75	13

as we read from the top to the bottom of the table. Those who take the position that scientists have had a great influence on the total space program to date are much less likely, for example, than those who do not hold this view, to say that scientists should have more influence. Secondly, this relationship holds regardless of the extent of involvement of a scientist's discipline with NASA, though those in the less committed disciplines show a slight tendency to be even more insistent on a larger voice for science. Whatever an individual's field or work, if he believes that scientists have been left out of the decision-making process, he finds this situation not to his liking.

The most interesting thing about the pattern of responses which emerges from the data in Table 41 lies not in its general similarities to, but in its differences from that of the preceeding one. Again, we see that when a scientist believes that

Table 41.

This table shows scientist's perceptions of how much influence they should have in their field in the space science program by discipline involvement and perceptions of actual influence.

	Involvement of Discipline			
	HIGH % who say scientists should have:		LOW % who say scientists should have:	
Actual Influence of Scientists on Space Science Program	More Influence	Things About Right	More Influence	Things About Right
Great Deal	42%		14%	
	27%	67%	20%	67%
Some	42		42	
	58	34	48	17
Very Little, None	16		44	
	51	31	52	30

the relevant segment of the scientific community has had a substantial impact on its portion of the space science program, he is satisfied. That is, he is unlikely to ask for still more influence - regardless of disciplinary involvement in space work. As before, his desire for influence increases as he sees less and less effective input from science, but note that the increase is not as great, proportionately speaking, for the space program as a whole. Compare the last row in the table with the same row in Table 40. Scientists who indicate that they or their colleagues have had little or no influence on decision-making in their 'field in the space science program' are less likely to ask for more influence than they would when faced with a similar question about the total space program. More of them see a discrepancy in the total space program between what is and what ought to be, by way of influence, than they do in the more limited area of NASA's space science endeavors.

Discussion and Conclusions

In this paper we have examined the images which scientists seem to hold of NASA. This is an important problem for two major reasons. First of all, since its inception the agency has been pursuing some goals directly related to the interests of at least certain segments of the Scientific Community. A substantial portion of the agency's resources has been given to scientists both in the agency and in universities and research centers for the support of work from which the potential payoff has served as a means for justifying to Congress and the public its allocation of resources. Decisions on the allocation of resources, at least in part, have been based on certain assumptions about which areas of science NASA ought to support and what kinds of problems are most relevant for a space science program to pursue. In light of its near decade of existence it seems reasonable to ask: How are these decisions viewed and what impact have they had upon science?

Secondly, and perhaps more importantly, NASA stands at a critical juncture in its history as an organization. It is faced with the question of what kind of an organization it is going to be after 1970. The state of the environment in which it must operate places some constraints on the alternatives it can reasonably consider and the policies which it can follow. Since the Scientific Community constitutes a major part of this environment, it is important to inquire into the distribution of attitudes within the Community towards the agency. This is one way of indicating what possible lines of action might be open for the future, or, perhaps, what lines of resistance might be encountered.

A report such as this, which relies on responses of individuals to a structured questionnaire, is certainly not the only nor even, necessarily, the best way to attempt to answer such broad questions. It's limitations, methodological and analytical, are many and its conclusions clearly have to be viewed and weighed in terms of much other pertinent information which it overlooks either through intention or ignorance. Nevertheless, it is one of the techniques available to the social scientist for throwing some light on policy questions and it does have some things in its favor. It enables us to survey, broadly, the opinion of many scientists or at least to examine their responses to a series of standardized, written stimuli in the form of questions. This data can, in turn, be subjected to a number of statistical checks and cross-tabulations which allow us to say something about the distribution of opinions and experiences in relevant sub-groups within the population studied. It affords the individual respondent a certain degree of anonymity in giving his answers, a freedom which he may not feel when his opinions are sought through other methods. He does not have to make his views "public" and defend them against others or, possibly, suffer adverse consequences because of them. On this basis, let us consider the major findings in this report.

1. The scientific relevance of the space program is greater for some disciplines than others. It is highest for fields like Astronomy, Atmospheric-Earth Sciences, Physics, and Engineering and lowest for ones like Microbiology, Genetics, Physiology, Chemistry and Mathematics.

2. The committments which scientists express towards NASA as a unique organization varies by discipline. Again, the sense of dependance on NASA is highest for those in Astronomy or, say, Physics

and lowest for those in the Life Sciences.

3. There is a considerable discrepancy between what scientists believe NASA is, in terms of the goals it has been pursuing, and what it ought to be. It is seen as an organization which has been motivated primarily by considerations of national prestige and an organization which ought to be oriented primarily towards basic research and exploration of space.

4. There is greater agreement over what NASA ought to be than over what it has been. Most feel it should be a research organization. Some feel it has in fact been one already, others that it has not.

5. Dissatisfaction with NASA as a research-oriented organization spills over into other judgments about the performance of the agency. A scientist who thinks NASA should be basic research oriented and finds that it isn't, questions the value of the agency's scientific programs and the desirability of continuing the organization at least at its present level of funding.

6. Dissatisfaction seems to stem primarily from a scientist's feelings that the Scientific Community has had very little influence on NASA's programs and ought to have a good deal more. Other factors like a scientist's discipline, whether or not he is a manager or researcher, whether or not he is a NASA employee, does not seem to be associated with his dissatisfaction with the agency.

7. The potential scientific payoff from NASA-supported research and space flight experiments is limited largely to those disciplines that have been highly involved in the space program. The Astronomers, Physicists, Atmospheric-Earth Scientists, and Engineers in our study, on the whole, feel that NASA has made possible a number of significant scientific contributions to their fields. Others, including Microbiologists, Bio-physicists, Organic Chemists, Physical Chemists and Mathematicians, see little of benefit coming from NASA-supported efforts.

8. The qualitative and quantitative impact of space technology on scientific research is limited primarily to those disciplines most closely involved in the space program. Scientists in these disciplines, however, are also most likely to stress the quantitative rather than the qualitative impact alone. One of the costs of space research is a great increase in red-tape, complexity of the organization of research, and the sheer amount of data which must be processed and analyzed.

9. Personal involvement in the space program - as a NASA employee, advisor, or space experimenter - is less important than disciplinary involvement for determining a scientist's evaluations of NASA's activities. Those who are most enthusiastic in their evaluations of NASA's activities are scientists who are both in disciplines which have been highly involved and have personally had some contact with the agency. Next comes those who are in the

more involved disciplines. The least enthusiastic are those who have had neither personal nor professional involvement with the agency. They see little benefit from NASA-supported work accruing to their fields of interest.

10. Most scientists in our study believe that the Scientific Community has had at least some influence on the space program, though they feel that the influence has been greater in the Space Science program per se than in the overall direction of the total program. Scientists in disciplines closely allied to NASA's work are much more likely to see evidence of this influence, however, than are those in more peripheral areas.

11. A majority of scientists in the study want a greater voice for science in the direction of the total space program and almost as many would like to see scientists have more of a say in the specific area of the Space Science program. In both instances, scientists in non-NASA related disciplines are more adament in this demand for increased influence.

12. The less influence a scientist believes the Scientific Community has had, the more likely he is to feel that it should be increased, especially with respect to the direction of the overall space program. This is true regardless of the discipline of a scientist. Physicists or Astronomers are almost as likely as Mathematicians or, say, Geneticists to want a greater role for scientists in decision-making if they feel that this role has been small or non-existant to date.